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Instruction

INSTRUCTION

UPON

THE ART OF POINTING CANNON,

FOR THE USE OF

YOUNG SEA OFFICERS.

TRANSLATED FROM THE FRENCH,
BY AN OFFICER OF THE U. S. NAVY.

WASHINGTON:
J. AND G. S. GIDEON, PRINTERS.
1848.

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PREFACE.

The following translation of a French tract, published in 1841, is offered to the young officers of the Navy by one of their brethren, in the humble hope that it may contribute, even a little, toward their instruction in the most important branch of naval science which they are called upon to master. It is not expected that this brief outline of several principles and maxims of gunnery, derived from theory, and compiled from the records of experiments abroad, shall do more than clear the way for the young sea officer, and invite him to go farther. But if this even is accomplished much is done; especially when it is considered that it is not only the duty, but the interest, of each to know, and to know well, the most important facts in gunnery. Some of them are recorded in the following pages, and have an authority which will induce confidence; for the facts here stated, and the principles laid down, need not be unlearned again, as is too often requisite with the notions picked up by the way-side in early life.

The progress made in naval gunnery, by the maritime nations of Europe, leaves it no longer a question with the sea officer of our country, whether he shall study the subject, or pick up so much of it only, as may be thrown in his way in the course of ordinary professional service. This was well enough when all others did it; no others do it now; and we must follow the example of our competitors in the study and practice of naval gunnery, or the young officers of the present day will not prove the worthy heritors of the fame bequeathed to them by the fathers of the Navy.

The time has gone by when the pursuit of nautical knowledge by study and application would depreciate the seaman in the eyes of sailors; and it is to be hoped that this barbarous prejudice derived from the bold navy on the other side of the Atlantic, and repudiated by it now, shall no longer find a refuge amongst ourselves. Knowledge in naval gunnery, like every other branch of knowledge, is only to be acquired by labor, assiduity, and study; and, like all other knowledge, carries power with it.

For fourteen years now the broadsides of the "Excellent"* have rung with the practice of her great guns with shot and shell. Some of the young officers who passed through this gunnery school are now captains in the British Navy; and most of those who shall in the future, command and fill the ships which *you* are to meet in service, will have had the advantage of this practical instruction. To old and young, the great gun and its service, from the arrangement of the magazine to the bursting of a shell *to time*, will be as familiar as the rifle is, to our frontier hunter.

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* Gunnery ship at Portsmouth, England.

And so with the French. They have always a cruising frigate, a dependence of the permanent school-ship, wherein to drill the young officers and seamen.

Unless we live in the fond belief that this knowledge is born with us—or we despise it—the young officers of the Navy (who will one day command it) must go heartily to work, and qualify themselves for the high responsibilities incident to their stations throughout their entire professional career.

THE TRANSLATOR.

September 14*th*, 1848.

INSTRUCTION

UPON

THE ART OF POINTING CANNON,

FOR

THE USE OF YOUNG SEA OFFICERS;

TRANSLATED FROM THE FRENCH.

I.

PRELIMINARY NOTIONS.

The vertical plane which passes through the axis of the bore of a gun is called the *line of fire*.

For the most part, the bullet rises a little above the direction given to the axis of the bore.

This effect is probably due to a slight motion of the gun, anterior to the expulsion of the projectile from the bore; the breech depressing and the chase rising at the explosion.

The motion of the bullet is then modified at each instant, by the resistance of the atmosphere, and by gravitation. This last force tends incessantly to draw it down until it finishes its flight by encountering the earth. The curve line which the centre of gravity of the ball describes in this flight, is called the *trajectory*.*

The curve presents its concave side towards the earth, and is always in the line of fire, when there is no active disturbing cause to make the projectile deviate. Let O S A be this curve, (fig. 1.) The point of departure O is nearly in the line of the prolongation of the axis of the bore. The point S, the most elevated portion of the curve, is the *summit of the trajectory*.

If we imagine a horizontal line, as O A, prolonged in the line of fire from O to A, where it intersects the trajectory, the length of this horizontal line will be the *range*. The point A will be the *drop*, or fall of the projectile.

The tangent to the summit S of the trajectory is horizontal.

The inclination B O A of the tangent, to the point of departure O, is called the *angle of departure*.

* I prefer "path of the shot."—EDITOR.

The inclination C A O of the tangent to the drop A, is the *angle of the drop*, or fall.

The section of the curve O S, which the moving body describes in the air, is called the ascending limb; and the section S A, which it forms in falling to the earth, is called the descending limb of the trajectory.

These two limbs, or branches, of the trajectory, are not symmetrical relatively to the vertical S D which passes through the summit—the two sections, O D, D A, of the horizontal O A, are not equal to each other; the second D A is the shortest. The angle of departure is less than the angle of the *drop*. With a given cannon, a similar charge, and a like projectile, a multitude of different ranges may be obtained. It is sufficient, to this end, to vary the inclination of the bore with the horizontal.

Let us conceive a series of experiments, in which the bullets would be received upon a horizontal plane, nearly at the level of the lower surface of the bore prolonged indefinitely. We might construct from the experiments a table, which would show the range corresponding to each inclination respectively, (fig. 2.)

If the ball, on leaving the bore, rises a little above the direction given to the axis of the piece, the range is nothing when this axis is horizontal, or, at all events, it is very small.

If it is imagined that the inclination of the gun, at first but very small, is made to increase gradually, the range will also increase at the same time, up to a certain angle which shall give the maximum of range, and which, for this reason, is called the *angle of greatest range*.

When the elevation continues to increase beyond this angle, the range will diminish; and it will become naught when the axis of the gun shall be vertical.

The angle of greatest range depends upon several circumstances. It is supposed, in the case of mortars, to be somewhat below 45°; but great importance need not be attached to the absolute determination of the true angle, inasmuch as the deviation of three or four degrees from the angle of 45 will not sensibly impair the range.

Hence it follows, from the foregoing, that there are two inclinations of the gun which afford the same range; one is below, and the other above, the angle of greatest range.

In general, a small elevation only is given to cannon and smaller firearms; the path of the projectile rises but little above the common level, and the fire is called *low or depressed firing*.

For the most part, mortars are established at an angle of 45°. Nevertheless, when it is sought to break through vaulted structures, a choice is made of a greater elevation. If the projectile in this case is thrown with a heavy charge, it rises to a very considerable height; and, at the moment of its fall, is impelled with prodigious velocity, and with nearly a perpendicular direction.

Sometimes, too, mortars are employed against masses of troops. In this case a less elevation than 45° is given, in order that the bomb may not lodge beneath the surface of the earth.

II.

SIGHTING, OR POINTING AT THE OBJECT, BY GIVING THE LINE OF DIRECTION AND ELEVATION IN SUCCESSION.

To point a gun, is to give it such a position that the projectile shall strike a determinate object; or, in other words, so that the path of the shot shall pass through a given point.

To effect this it is requisite, 1st, that the vertical plane, *or line of fire*, shall pass through the point aimed at; 2d, that the piece shall have the proper elevation.

When the axis of the trunnions is horizontal, the position of the line of fire is independent of the inclination of the axis of the gun; in fact, although the inclination should change continually, the axis of the piece remains in the same vertical plane; and it is this plane which is the line of fire. Hence it follows that, without regard to the elevation, the first step should be to adjust the gun, so that the line of fire should pass through the point aimed to be hit; and this is termed *giving the direction.*

The straight line, which passes by the most elevated points of the breech and muzzle, is called the *natural line of sight*, or line of metal; it is evidently contained in the line of fire.

When the axis of the trunnions is horizontal, the same points on the breech and swell of the muzzle are always the most elevated, whatever be the elevation of the cannon. The positions of these two culminating points of the base ring and muzzle, are usually indicated by a longitudinal score cut in the metal.

If the gun be directed so that the line of metal passes through the object, we may be sure that the last is also intersected by the line of fire. *Thus, when the axis of the trunnions is horizontal*, the true direction is given to the gun by causing the prolongation of the line of metal to pass through the object aimed at.

This process, of easy execution with a cannon of any kind, is not applicable to a mortar; the carriage of which does not admit of the various elevations. Besides, mortars are generally mounted behind breastworks, which preclude the view of the object to be battered. In this last case, two upright pickets are planted upon the crest of the work, in a line as near as practicable with the object, and the line of fire of the mortar made to coincide with that of the pickets.

To effect this, a man furnished with a plummet is placed behind the mortar; the plumb line and the pickets are brought into the same vertical plane, and the mortar is then adjusted to coincide with it, by bringing the orifice of the vent and the upper point on the muzzle to the same line. The sighting point on the muzzle of the mortar is usually marked with a score.

Sometimes a packthread is stretched from the crest of the work to a picket planted in rear of the mortar upon the proper line of direction, and the vent and muzzle mark of the mortar made to coincide, to give it the true direction. There only remains to give the piece of ordnance the proper elevation.

When the object to be battered is nearly on a level with the bore, the distance between them is the range, which it is requisite to obtain. Then the table, the construction of which has already been explained in the first part, will indicate the degree of elevation necessary to be given to the piece.

Ordinarily a squared piece of board, on which the quadrant of a circle has been carefully inscribed, is used for this purpose. Let A B C D be the quadrant, (fig. 3,) and A, the centre of the arc, is one of the summits; the radius is equal to a side of the square. Attach a plummet, A P, to the point A, and divide the arc into degrees. The zero of the graduation being at B, the side of the board, C D, is placed against the face of the muzzle, so that the plane of the instrument shall be vertical. The angle, P A B, is that which the face of the muzzle makes with the vertical, and it is equal to the inclination of the gun, since the face is supposed to be perpendicular to the axis of the bore. It is only necessary, then, to turn the gun upon the axis of its trunnions, until the angle P A B shall have the value called for by the table.

The elevation may also be given, by placing the instrument upon the exterior cylindrical surface of the gun. To do this, keeping the plane of the board vertical, apply the side B C (fig. 4) upon the upper side of the cylinder, and it is apparent that then the angle P A B will indicate the inclination of the piece.

But, in adjusting the elevation, the position of the axis of the trunnions may have been disturbed. Thus, if a mortar be in question it must be verified, after this operation, that the orifice of the vent and sight mass on the chace be still in the line of the marks.

The same plan is followed with the long guns. An observer, with a plumb line, stands behind the gun, and brings the target and the muzzle sight in line for example, and verifies if the same line includes the sight mark on the breech.

This means might be employed to adjust the direction, if any obstacle should interpose between the line of metal sighting and the object to be battered.

When the object to be reached is not on a level with the point of departure, the distance which separates these two points is no longer the range, in the sense in which the latter was defined in the first part. For example: let B (fig. 5) be the point to be reached by the projectile, above the horizontal O A, from the point of departure O; the curve O S A will represent the path of the shot. Now, by the first definition O A is the range, whilst O B is, in fact, the distance from the point of departure to the target; and if the trajectory is depressed, the range O A is greater than the distance O B. In order that the trajectory shall pass by the point B, the gun must be elevated for the range O A.

Thus, in depressed firing, when the point to be battered is above the level of the point of departure, the elevations which it is necessary to give the gun will surpass those which are given by the table, as corresponding to the distance of the object from the cannon.

The contrary is the case when the object to be battered is at B′, below the horizontal from the point of departure; the range O A is less than O B′.

Therefore, in depressed firing, when the object is less elevated than the point of departure, a less elevation must be given to the piece than the angle indicated in the table, which corresponds to its distance from the cannon.

The process of pointing cannon just described is very slow, and the indications of the quadrant are by no means accurate, arising not only from the small limits within which its construction is confined, but because the plumb line is incessantly disturbed by the agitations of the air.

These observations, however, apply with less force to the service of mortars. In fact mortar firing is always very slow, and as it is executed under high angles of elevation, a slight variation in the angle thereof has little influence upon the range.

If the axis of the trunnions is not horizontal, which might well happen through faulty construction of the platform, the line of fire of the mortar will not then pass by the vent and the sight mark, or the muzzle. For example: if the left trunnion is the lowest, the vent and muzzle mark will be found to the left of the line of fire, and at unequal distances from the vertical plane, because of the unequal diameters of the piece at these two points. Generally, in mortars, the diameter at the vent is less than the diameter at the muzzle; the score then is farther removed from the line of fire than the vent. The right line, therefore, which joins the two points being produced beyond the piece, continues to the left of it, more and more, as it is prolonged; so that, if adjusted to the plane of the picket markers, the line of fire would be made to pass to the right of the object fired at, (fig. 6.)

This line must then be made to pass to the left of the object aimed at. This inconvenience may be remedied by inserting a wooden peg into the vent hole, which shall project just enough to make the straight line joining it with the score on the muzzle parallel to the axis of the bore of the piece; the distance which separates them is too small to affect sensibly the direction of the fire.

The peg should be arranged so as to insert a constant quantity. To determine the length of its projecting part, turn up the mortar vertically, apply a spirit level to the face of the muzzle until it is horizontal, and then cut off the peg when it touches a plumb line which passes through the sight score.

Mortars, mounted on beds, are employed in bomb vessels, and for seacoast defences.

In this case the different ranges can only be obtained by a change of charge, since the inclination of axis is permanent, at least so long as the platform is horizontal; which is supposed in the tables of range.

A similar mortar should only be mounted on shore, on a platform assured to be horizontal, and then it is conveniently pointed when the vertical plane, determined by the orifice of the vent and the culminating point on the muzzle, passes also through the point to be attacked.

If, at sea, this same condition appears to be fulfilled; at the instant when the bed is nearly horizontal, the mortar should be fired.

III.

POINTING BY THE NATURAL LINE OF SIGHT.

Generally, the great guns used for depressed firing have a greater diameter at the breech than at the muzzle, so that the natural line of sight encounters the axis produced in front of the face of the muzzle. The acute angle made by the intersection of these two lines, becomes equal to the angle of elevation when the line of metal is horizontal. It is, hence, often termed the natural angle of sight. The name of *point blank range* is given to the range obtained when the line of metal is horizontal.

This range varies with the nature of the projectile, and with the powder charge. Experiment alone can establish the extent of it, when the projectile and powder charge are given. In this case, if a straight edge is placed upon the culminating points of the breech and muzzle, and made horizontal by the level, the point at which the projectile falls, when fired over a plain surface on a level with the bottom of the bore at the face of the gun, will be the *point blank range* for the gun.

When the natural line of sight is parallel to the axis of the gun, the point blank range will not be absolutely nothing, but it is very small.

TABLE OF POINT BLANK RANGES.

NATURE OF GUN.		PROJECTILE.	CHARGE. LBS.	RANGE. YARDS.
Land artil'y.	24-pounder siege	Solid shot	8.82	746
	Bomb cannon, 8-inch	Hollow and sabot	4.41	547
	Howitzer, 12-pounder	Idem ..... Idem	.595	250
Sea Artillery.	30-pounder, (long)	Solid	11.02	875
	Idem	Idem	8.27	802
	Idem	Idem	5.51	689
	Idem	Hollow—sabot	8.27	919
	Idem	Idem	5.51	815
	30-pounder, (short)	Solid	11.02	995
	Idem	Idem	8.27	930
	Idem	Idem	5.51	804
	Idem	Hollow—sabot	8.27	1,047
	Idem	Idem	5.51	932
	Bomb cannon, 30-pounder	Solid	4.41	483
	Idem	Hollow—sabot	4.41	578
	Idem	Idem	3.30	495
	Bomb cannon, 80-pounder	Hollow—sabot	7.72	616
	Idem	Idem	4.41	513
	Carronade, 30-pounder	Solid	3.53	1,074
	Idem	Hollow—sabot	3.53	1,046
	Carronade, 24-pounder	Solid	2.86	1,047

Let (fig. 7) O be the point of departure.
O A, the horizontal from this point.
C D, the line of metal, also supposed horizontal.
O S A, the path of the projectile.
Then O A is the point blank range.

In general, the angle formed by the natural line of sight, (or line of metal,) with the axis of the bore, is very small; so that the trajectory O S A is very depressed.

The line of metal being produced, intersects the trajectory in two points, E and F, the first being always very near the gun. The distance which separates the two parallels, C D and O A, is very small in comparison with their length; so that, practically, these two lines may be considered identical. Hence, *the point blank range is considered equal to the distance D F, comprised between the gun and the farthest of the two points, at which the trajectory intersects the natural line of sight.*

Abstraction is made of the distance which separates the natural line of sight from the point of departure, and figure 8 is substituted for figure 7; in the former of which the straight line C O A represents the direction of the line of metal sight, and O X that of the axis of the bore. The first of the two points, where the line of metal encounters the trajectory, is thus confounded with the point of departure.

It is clear, that *when the point to be battered is placed at a distance equal to the point blank range, in order to point the gun the line of metal must be laid upon the object.*

Rigorously, this takes for granted that the object is horizontal with the point of departure; nevertheless, the same principles may be applied, although there should in fact be a slight difference of level in the two points, seeing that, in the case where the line of metal is no longer horizontal, but is either a little above or below it, the points where it encounters the trajectory remains at nearly the same distance from the gun.

Every point, M, of the trajectory (figs. 7 and 8) situated within the point blank range, is above the line of metal, at least, if it be not very near the muzzle of the gun.

The vertical line M P, (fig. 8.) comprised between the point M and the natural line of sight O A, is called *the depression* of the line of metal below that point. This depression does not vary sensibly when the line of metal, ceasing to be horizontal, assumes an inclination either way.

If it be supposed that the point M, at first very near the point A, should be approached gradually to the gun, the depression M P would continue to increase until it attained a maximum, and would thence diminish.

If we had a table which gave the ranges corresponding to each degree of elevation, another table might be formed, showing the depression of the line of the natural line of sight at every intermediate distance below the trajectory. For example: let figure 9 represent the line of fire, of which O M is the horizontal length of any range. The table will indicate the elevation of the gun which corresponds with this range, and the straight line, o x, will represent the axis of the bore produced. This being established, the dimensions of the gun being given, we know the angle of the natural line of sight; or, in other words, the angle made by the line of metal with the line of the axis. Trace the direction of this line of metal as O A. The length of the vertical M P, contained between the point M and the right line O A, will be the depression of the line of metal sight below the point M on the trajectory.

It would require, therefore, only some geometrical constructions to form the table sought.

From these premises it follows, *that when the object is within the point blank range, the piece is to be pointed by laying the line of metal upon the vertical of A, but as much below the object as the depression due to the distance calls for, in the table.*

For field pieces this depression is nearly 3.15 inches for every thirty-two feet within the point blank range, and so long as the distance of the object does not surpass half that range. In default of a table, resort may be had to this rule, to wit: when the distance is nearly equal to half the point blank range *point very low*, and then, for smaller distances, reduce the depression from its maximum in the ratio indicated above as due to every thirty-two feet.

Every point, N, of the trajectory situated beyond the point blank range, (fig. 8,) is below the direction of the line of metal O A. The length, N A, of a vertical, contained between the point N and the line of metal, is called the *elevation of the line of metal above that point.*

A table of these elevations might be formed in the same manner as for the table of depressions.

Hence, *when the point to be fired at, or the object, is beyond the point blank range, the piece is pointed by directing the line of metal in the vertical of it, but above the object, by the same quantity of elevation indicated by the table.*

Thus, whatever may be the position of the object to be battered, the pointage is effected by a single operation.

It must not be forgotten, that the scores marked upon the breech and swell of the muzzle, only give the position of the line of metal in the case, when the trunnions are horizontal; but, whatever may be the situation of this axis, the most elevated metal of the breech and muzzle always determines the line of metal, and this mode of sighting does not cease to be applicable.

Sometimes there is a considerable difference of level between the point of departure and the object, relatively to their distance from each other. In this case, when the *object* is *most* elevated, the pointing must be higher than the elevation given in the tables; and, in a contrary case, the pointing must be lower.

When the infantry musket has the bayonet fixed, the natural line of sight, which passes over the most elevated points on the breech and socket of the bayonet, is very nearly parallel to the axis of the bore. The point blank range here becomes very small; and, unless the object is very near, the aim must always be taken above the mark.

To hit a man in the middle of the body, at the distance of 109 yards, aim must be taken at the breast; at 218 yards, at the upper part of the cap. These results suppose the ground to be nearly horizontal, the diameter of the balls equal to nearly $0^{m}.0163$,* and the charges 80 to the killogramme.

When the infantry musket is without bayonet, the natural line of sight passes over the most elevated points of the breech and muzzle of the barrel; it is no longer parallel to the axis; the point blank is increased to 127 yards. Beyond this distance the aim must be above the object, and, within this range, the pointing must be below the mark.

The visual ray, proceeding from the person who takes the aim, along

* .63 of an inch, nearly.

the line of metal, will be intercepted by the barrel, if the gun be elevated to range for an object which lies beyond point blank; since, in this case, the true line of sight passes above the target. This mode of pointage becomes then illusory, unless there be found in the vertical of the object aimed at, some other object, elevated sufficiently above it to be in view, and to guide the aim. This condition can rarely be fulfilled on shore, but it is not thus at sea. The dimensions of men-of-war, of all nations, are known accurately enough to assign the point of the masts, on which the line of metal should be laid in order to hit the hull at a given distance beyond the point blank range; provided, always, that this distance be not too great.

As, then, the piece of ordnance is never at rest at sea, the moment, when the line of metal is on with the selected point, is to be seized to let off the gun.

IV.

POINTING BY THE HAUSSE, OR SIGHTS, WHEN THE DISTANCE IS GREATER THAN THE POINT BLANK RANGE.

It has been shown that the sighting by the line of metal is illusory, when the distance of the object from the gun surpasses the point blank range; recourse, in this case, must be had to another process:

Let O be the centre of the face of the muzzle, (fig. 10.)

O A, the horizontal line from that point.
A, the point of drop.
O X, the direction of the axis of the piece.
C, the most elevated point of the breech.
C G, the radius of the base ring at C.
D, the most elevated point of the swell of the muzzle.
D I, the radius of the swell at D.

The line C D is the line of metal, or natural line of sight, the prolongation of which is supposed to pass above the point A.

The line A D, which is determined by the point of drop A, and the point D on the upper part of the swell, if prolonged, will pass above the point C, the highest at the breech, and encounter the radius C G at the point E.

When we have a table of ranges corresponding to the different elevations of the gun, it is easy to determine the position of the point E, since the range O A, which it is desired to obtain, is known.

In fact, this table gives directly the angle X O A, the angle of elevation of the gun. Besides, the distance D I being extremely small, relatively to the length of the range O A, the right line D A may be considered as horizontal, and the acute angle which it makes with the axis of the piece is practically equal to the angle X O A.

This being granted, the known dimensions of the gun enables us to construct the trapezium C D i G; and if a straight line is drawn from the point D, making, with the prolongation of I X of the line G I, an acute angle equal to X O A, this line will cut C G produced, precisely at the point E.

The distance, C E, is the quantity which it is requisite to elevate the culminating point of the breech, following the radius C G produced, in order that the point C shall coincide with the line D A which passes by the point of drop, and the culminating point of the tulip. It is called the *hausse.* From the foregoing data, therefore, a table of *hausses* may be constructed, the elevations of which shall correspond with all the ranges which may be obtained in practice.

The hausse gives an artificial line of sight, E D A, which ought to pass directly by the point aimed at, A. The sighting may then be executed by the means of this line.

Thus, *when the object is at a greater distance than the point blank range, the hausse is elevated to the mark indicated by the table as corresponding to the range, (which must be known or estimated,) and the artificial line of sight is made to pass from the object, touching the most elevated point on the muzzle, to the extremity of the hausse.*

For field pieces, in default of tables, make use of the following rule: elevate the hausse .35 of an inch for each 109 yards over and beyond the point blank range.

The graduated plate secured to the breech of field pieces, is of very ready application in practice; but it must be observed, that the middle of its upper extremity is never the most elevated when the axis of the trunnions is not horizontal. Suppose, for example, that the left trunnion is the lowest; then the score on the tulip and the middle of the plate deviate to the left of the vertical plane in which is the line of fire; but the score on the swell being nearer to the axis, remains also nearer to the vertical plane, as it deviates less than the end of the hausse, which is on a longer radius. The line of sight determined by these two points, thus unequally inclined from the vertical plane, will intersect the line of fire in front of the gun, and will pass to the right of it if prolonged, (fig. 11;) and, further, this line will have less elevation than the one given when the trunnions are horizontal; therefore, when the left trunnion is the lowest, let the line of sight be directed to the right and above the object.

But if the difference of level in the trunnions is small, and if, at the same time, the object sighted upon has a certain extent of surface, these causes of error may be neglected. In those cases where it would be necessary to regard them, it would be better to omit the use of the hausse plate, and substitute a wooden stem, placed on the upper part of the base ring, when wanted to lay the gun. The artificial line of sight would then pass by the upper extremity of this stem and swell of the muzzle.

The hausse upon the breech singularly facilitates the pointing, but it can only be applied to distances greater than the point blank range. For inferior distances the pointing is done by the aid of the line of metal; but, in this case, it is very difficult to appreciate, by the eye, the necessary quantity of depression of the muzzle below the object to be attained. And besides, it frequently happens that the line of sight prolonged encounters the ground before the object. There might, indeed, be placed a sight upon the swell of the muzzle, and the artificial line of sight made to pass by its point and the culminating point on the breech; but this would be found very incommodious in practice.

V.

SIGHTING BY THE HAUSSE, WHEN THE NATURAL LINE OF SIGHT IS PARALLEL TO THE AXIS OF THE GUN.

The hausse could be used for taking aim at all distances, if the line of metal were parallel to the axis of the gun, since the point blank range in that case would be, if not absolutely *nothing*, at least very small. This arrangement was carried out in the construction of the ancient 8-inch howitzers, the 6-inch of Grebeauval, and in the 24-pounder howitzer of the year XI. In like manner, it can be arranged for any other gun, by adapting to it an appliance which shall augment, by a proper quantity, the smaller diameter to equal that of the larger, generally at the base ring. This is precisely what is practised with the navy guns.

A front sight mass is fastened between the trunnions, for the purpose of supporting the forward sight; and a stem, or runner, which traverses in a box, is fitted to the breech. The runner terminates in a head, through which, in the direction of the length of the gun, is cut a notch, like the breech sight of a rifle. When the axis of the trunnions is horizontal, the bottom of the notch and the point of the forward sight are in the plane of the line of fire; and when the head of the stem rests on the box, the straight line, which passes by the tip of the front sight through the notch, is parallel to the axis of the bore.

This line may be considered as confounding itself practically with the trajectory, up to a certain distance; which depends upon the nature of the gun, the amount of the charge, and the character of the projectile.

Thus, when the object to be battered does not exceed this distance, the head of the runner or hausse must rest on the box, at its least elevation, and the gun laid so that the line of sight shall pass through the notch, over the tip of the front sight, and directly upon the object.

When the object is further removed than the range given by the above method, and when the actual distance is known, the stem is elevated by a quantity equal to the hausse indicated in the tables as due to the distance; and, this done, the gun is laid upon the object directly by the sights, as in the preceding case.

When the axis of the trunnions is not horizontal, the line determined by the hausse, and the front sight, is no longer in the plane of the line of fire, and there results the inconveniences noticed in § 4, as belonging to the service of field pieces; but the dimensions of objects, usually fired at in the service at sea, permits us to neglect these causes of error.

VI.

RICOCHET FIRING.

The firing is said to be direct, when the projectile is expected to reach the object without touching the earth in its path.

Ricochet firing, on the contrary, is when the piece is directed so that the projectile shall graze the earth or water at several points along its path.

Projectiles thrown from field pieces only ricochet over ordinary ground, when falling at an angle of not more than 7 or 8 degrees; therefore, if the ground be horizontal, the elevation of the gun should be less than 7 degrees, since the angle of drop exceeds the angle of departure.

In pointing field pieces, so as to hit the ground supposed horizontal, at a distance somewhat within the point blank range, a succession of grazes can be obtained over a distance of about a thousand yards.

This ricochet range will be augmented, if the level of the ground depresses towards the object; but if the ground rises, on the contrary, the extent of the ricochet will be restrained; and often this kind of firing becomes impracticable.

Ricochet firing is effectively employed in the attack of fortified places.

Suppose, for example, that the straight lines, B A and A C, (fig. 12,) represent the interior crests of two faces of the work to be bombarded. The gun should be so planted, that its plane of fire shall be parallel to the straight line A B, and at a distance from it equal to the thickness of the terre-plein.

The fire is directed in such a manner that the projectile, grazing the interior crest A C, touches the terre-plein at a small angle. The bullet, making several successive bounds, thus sweeps the whole length of the face, of which A B represents the interior crest. By this means the shot, in penetrating into the interior of the work, describes the descending branch of the trajectory. Thus the summit of the curve of the trajectory is found between the gun and work, but near enough to this last to ensure a small angle of drop. The charge, therefore, ought to be regulated to satisfy this condition; to determine which, regard must be had to the elevation of the work, and its distance from the gun. The usual distance is within 450 yards.

Generally, only reduced charges are employed; by which means, the earth on the ramparts being firm and smooth, the ricochet is procured whenever the angle at which the bullet falls does not exceed 10°.

When that angle is near 10°, the ricochet is known as weak; the first point of drop is found at about 14 yards from the interior crest A C, supposed to be elevated 7½ feet above the terre-plein.

When the projectile reaches under a small angle, it sweeps a large portion of the face of the work without touching it; the ricochet is then called intense.

Bullets ricochet on water when it is undisturbed, if the angle at which they encounter it does not exceed five or six degrees.

VII.

ANOMALIES IN FIRING.

Whatever precautions are observed to make the circumstances of each individual fire alike in all particulars, frequent anomalies will, nevertheless, present themselves.

The powder will not communicate the same velocity to the ball in all cases; the ball itself does not depart under a like angle; its form may sensibly differ from a sphere; its centre of gravity is more or less remote from the centre of figure. All these circumstances, besides others not named, exert an influence over the range.

The tables of ranges should be regarded as presenting the mean results of experiments made with selected balls, with powder of known good quality, and with guns in a good condition. Individual ranges may, therefore, differ materially from those which are indicated by the tables.

The extent of the deviations increases with that of the distance. Thus, at great distances the fire becomes very uncertain.

VIII.

FIRING WITH TWO SHOT.

Double shotting is practised only in the navy. An imaginary trajectory, intermediate between the paths of the two shot, is assumed as the true, and the curve described by the mean is projected so as to pass by the centre of the object; and, upon this principle, the tables for two shot are constructed.

Firing with two shot may be very effective within 440 yards; the vertical separation of the two balls will not exceed 4½ yards, whilst the horizontal separation is even less.

IX.

FIRING WITH CANISTER SHOT.

The small shot used by the land artillery are encased in a tin canister; they are of cast iron for siege and heavy ordnance, and of wrought iron for field pieces.

In the sea service the balls are of cast iron, and are made up into grape around an iron stem, and wrought iron stool riveted to it. A coarse canvas bag is secured to the stool, the balls filled in, and the whole is frapped around with marline. The stool plate is put next to the cartridge in loading.

Navy guns are supplied with both canister and grape shot.

Each ball of the stand of grape, or canister, when fired, describes a particular trajectory; the fire is so directed, that a mean trajectory of all the paths described by the balls, respectively, shall pass by the object fired at.

The range of grape and canister is far less than that of the proper bullet of the calibre; the hausse, therefore, will be much more elevated for equal ranges, which will be indicated by special tables.

The separation of these balls is called their dispersion. The dispersion of balls is proportional to the distance.

In land artillery the dispersion of balls is generally estimated at a tenth nearly of the distance; but no exact experiments have yet been made to verify the fact. Simply prescribing that shot of this description should not be employed but within 550 yards.

The annexed tables of practice will indicate the dispersion of balls, which enter into the composition of grape shot adopted in the navy.

* * *

X.

FIRING WITH ROUND AND GRAPE SHOT.

The round shot should be introduced into the gun immediately after the cartridge.

The stand of grape is put in on the round shot. By this disposition the grape shot are less dispersed, and diverge from the round shot less promptly.

The dispersion is then very little more than when the grape is fired without the round shot.

The firing with round and grape together, ought to be confined to the distances recommended in the case of grape alone.

The hausses, or elevation of the runner, are calculated so that the path of the round shot shall pass by the centre of the face of the object fired at.

If the stand of grape is placed on the cartridge before the round shot, the dispersion of the former will be doubled.

XI.

MEASURE OF DISTANCES.

The tables of ranges are not applicable to the regulation of the firing, except for known distances.

If there should be an object near the target, the height of which, A B, is known, (fig. 13,) the line of metal, C D, should be directed upon the upper portion of this object; then, with the gun thus laid, the hausse is elevated until the line of sight is had with it directly upon the lower part, A, the hausse elevation being C E, and deduce the proportion.

The hausse C E is, to the length C D, comprised between the two points of sight, C and B, as the height, A B, of the object is to the distance, A D, which is sought.

Thus the natural line of sight is to be directed to an object 6¼ feet in height, say at the crown of the hat of a man on foot; sight is then taken at the feet, by means of the hausse, without disturbing the gun; then, by searching in the following table, the distance, corresponding to the elevation of the hausse, is obtained.*

---

*The table is omitted, because only applicable to the guns named, which have a line of metal peculiar to themselves. It suffices to have given the principle on which distances may be calculated by means of the hausse, provided the elevation of one of two distant objects above the other be known; for example, the truck of a frigate above the water line, or gun-deck ports.

Chapter 12, which contains the tables of mortar ranges, is omitted.

Chapters 13 and 14 are also omitted, as affording no points of comparison with our sea ordnance, from which useful results could be deduced.

XV.

TABLES OF RANGES OF SEA ORDNANCE, COMPILED FROM THE EXPERIMENTS MADE AT GAVRE.

Each piece of ordnance is supposed to be fitted with a front sight, so that at all distances, within the limits of its range, the pointing can be made by the assistance of the hausse, (§ V.)

In the same gun, all the fires with double shot, of any description, are made with the same powder charge.

Two shot should not be fired when the distance exceeds 430 yards, seeing that the vertical separation of the two balls from each other would then be more than 13 feet.

As a general rule, grape or canister should not be fired at distances which would cause a divergence of the small shot more than 33 feet.

Thus, with the long and short 30-pounder guns, and the 30-pounder shell gun, grape should not be fired at distances greater than 325 yards, and canister beyond 220 yards. These limits should be still further confined in the case of carronades. With these last the effective range with grape ceases beyond 220 yards, and the canister should not be employed except within 160 yards.

Having regard to the distance within which each of the above combinations ought to be circumscribed, the same table of ranges will be found common under the four following conditions:

1st. With two round shot.
2d. One round shot and one stand of grape.
3d. One round shot and one canister.
4th. One stand of grape, without round shot.

It suffices to augment the elevation given by the hausse, as due to the above, by one-half, to obtain that which corresponds to the charge of a canister shot without a round shot.

NOTE BY THE EDITOR.

[The table of ranges here alluded to is omitted, because the point of departure, to wit, the line of metal, is peculiar to the gun, and furnishes no means of comparing the ranges with, or applying them to, our guns.—*Edr.*

The table, however, indicates, as a general fact, that the hausses (or elevation of the gun) are common with the charge of a $\frac{1}{3}$ and one round shot, and shell with a powder charge of $\frac{1}{4}$ up to the distance of 1,418 yards inclusive. And, further, that with one round shot and charge of a $\frac{1}{4}$th, or with a shell and a charge of $\frac{1}{6}$th, the hausses (or elevation of the gun) are the same; or, in other words, give equal ranges.

Again, the range obtained with two round shot, with a charge intermediate between a $\frac{1}{7}$th and a $\frac{1}{8}$th, require the same elevation as a shell with a powder charge of a $\frac{1}{10}$th, at distances within 985 yards.

In the case of carronades, similar powder charges give the same ranges to both solid shot and shell, within 985 yards distance.

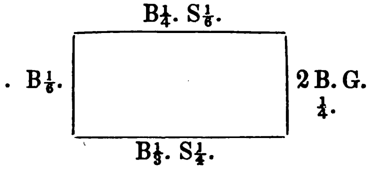
In order to facilitate the service of navy guns, care has been taken to engrave upon the stems of the hausses the ranges corresponding to its elevations. But not to complicate the use of them by multiplying the divisions, the marks have been made to correspond to an exact unit, and represent each so many cables' lengths distance; the cables' length being taken at 200 metres, or 218.6 yards.

The firing with double shot exact a different marking, or higher elevations of the hausse; the marking may, in this case, represent the half cable's length.]

1*st*. *Of the long and short* 30*-pounder cannon.*

The face of the moveable runner, which looks towards the cascable of the gun, is marked with the graduation common to the ranges of solid shot with a powder charge of a third, and shell with a powder charge of a one-fourth the weight of the projectile. It is marked B⅓. S¼.

Thus, ...



The face turned towards the muzzle is marked B¼. S⅙.; the graduation, which answers equally for the solid shot with a charge of a one-fourth, and for the shell with the charge of one-sixth up to the distance of five cables. Beyond this last, this graduation is applicable only to the solid shot.

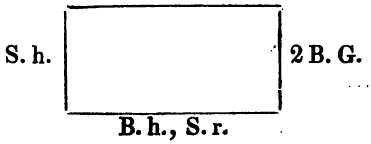
On the left face is marked B⅙, and graduation proper for solid shot with a charge of one-sixth.

The graduation corresponding to the ranges and charges for double shot of any kind is placed on the right side of the runner, and is marked 2 B. G. To this side recourse must be had in pointing; first, with two round shots; secondly, with a round and stand of grape or canister; thirdly, for a stand of grape alone; and, in each case, with the powder charge of one-fourth.

2*d*. *Bomb cannon*, 30*-pounder*.

The face of the runner, which is turned towards the cascable, is marked B. h., S. r. The graduation on it is common to the range of the solid shot with the high charge, (B. h.,) and shell with the reduced charge, (S. r.,) at distances not exceeding eight cables; beyond that the graduation only answers for the solid shot.

Thus, ...



On the left face is marked S. h., and the graduation due to the ranges with *shell* and *high* charge.

On the right face is marked 2 B. G., and the graduation corresponding to the ranges of double shot, to wit: two balls, grape; which is to be fired with the high charge, (h.) This side is used with the following charges of metal:

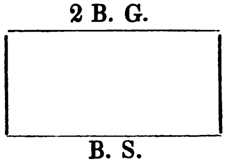
1. Two round shot.
2. One round shot and stand of grape or canister.
3. One stand of grape.

When the canister alone is fired, the hausse is elevated by one-half the quantity indicated by the side 2 B. G., as due to the range in the cases of 1, 2, 3.

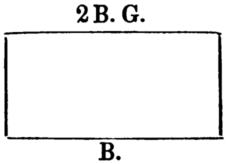
3*d.* 30-*pounder carronade.*

The stem for this hausse only bears two graduations. The face towards the cascable carries the graduation, common to the ranges of both solid and hollow shot, up to eight cables' lengths; beyond this distance the graduation is only applicable to solid shot. This is marked B. S., (ball, shell.)

On the face toward the muzzle, and marked 2 B. G., is found the graduation for double shotting. For the manner of serving them, see what is said under the head of bomb cannon.

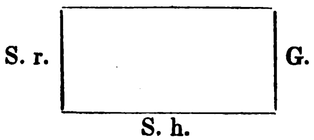


4*th.* 24, 18, *and* 12-*pounder carronades.*



The face turned towards the breech, and marked B., carries the graduation for the solid shot, (ball.) On the face turned towards the muzzle is marked 2 B. G., or the graduation for double shotting.

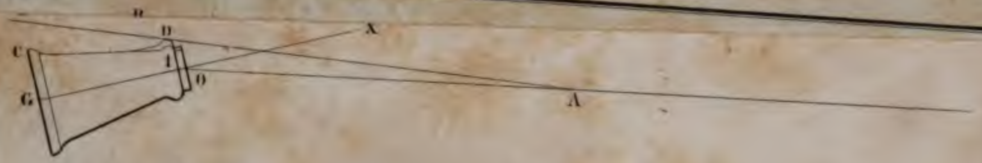
5*th.* 80-*pounder bomb cannon.*



The face turned towards the cascable is marked S. h., (*shell, high charge,*) and carries the graduation for the range of shells with the high powder charge, or charge intermediate between the 11th and 12th, the weight of the solid shot.

The graduation for the range of shell with reduced charge, charge of a 20th, is placed on the left.

The right face is marked G., and is graduated for the range of grape or canister.



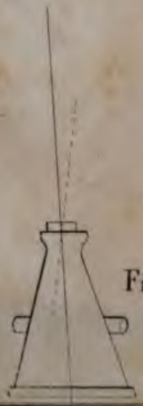


Fig. 11

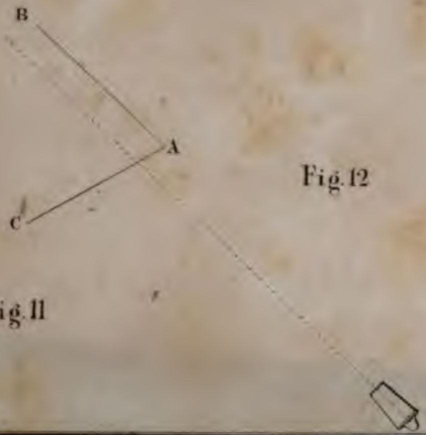


Fig. 12

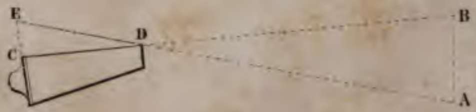


Fig. 13

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